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(71) Applicant
Flachglas Aktiengesellschaft

(Incorporated in FR Germany)

Otto-Seeling-Promenade 10-14, D-8510 Furth/Bayern, Federal Republic of Germany

(72) Inventors
Hans Bause
Dr. Rolf Groth

(74) Agent and/or Address for Service
Forrester Ketley & Co
Forrester House, 52 Bounds Green Road, London, N11 2EY

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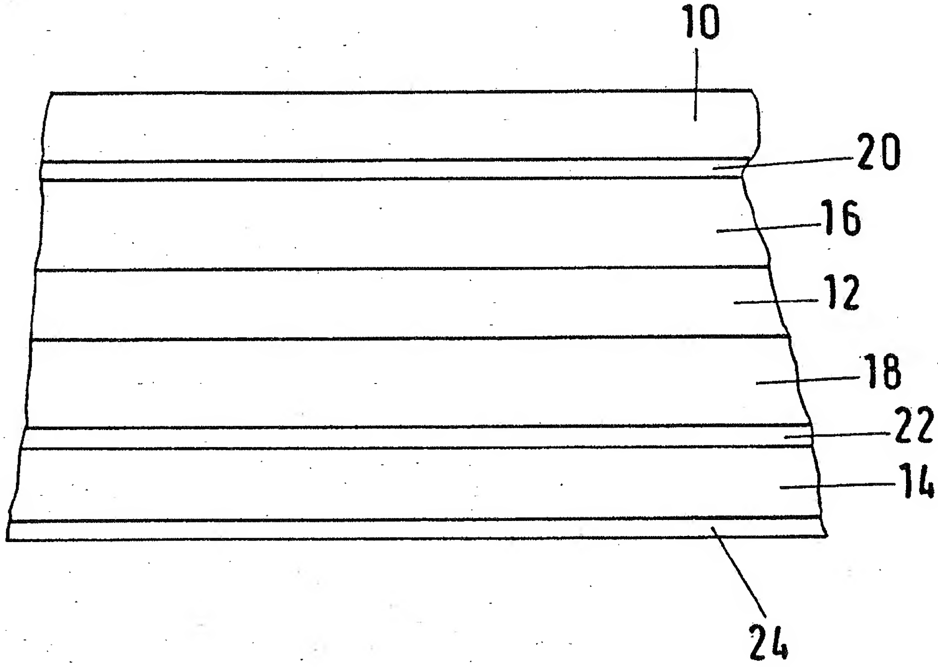
(54) Multiple sheet insulating glass for cold storage chambers

(57) Multiple sheet insulating glass for a window-like door for separating a cold storage chamber having a relatively low air temperature from surroundings having a higher air temperature, the glass comprising an outer sheet facing the surroundings and an inner sheet facing the cold storage space and separated from the outer sheet by means of at least one intermediate space. The outer surface of the inner sheet facing away from the intermediate space is exposed to the atmosphere of the cold storage chamber. The glass is used for a cold storage chamber with forced air circulation and has a coefficient of thermal transmission of 2 W/m²k, preferably 1.6 W/m²k. The outer surface of the inner sheet (14) is provided with an infra-red reflecting coating (24), the thermal reflectivity of which is more than 50% in the wavelength range above approximately 4 μm.



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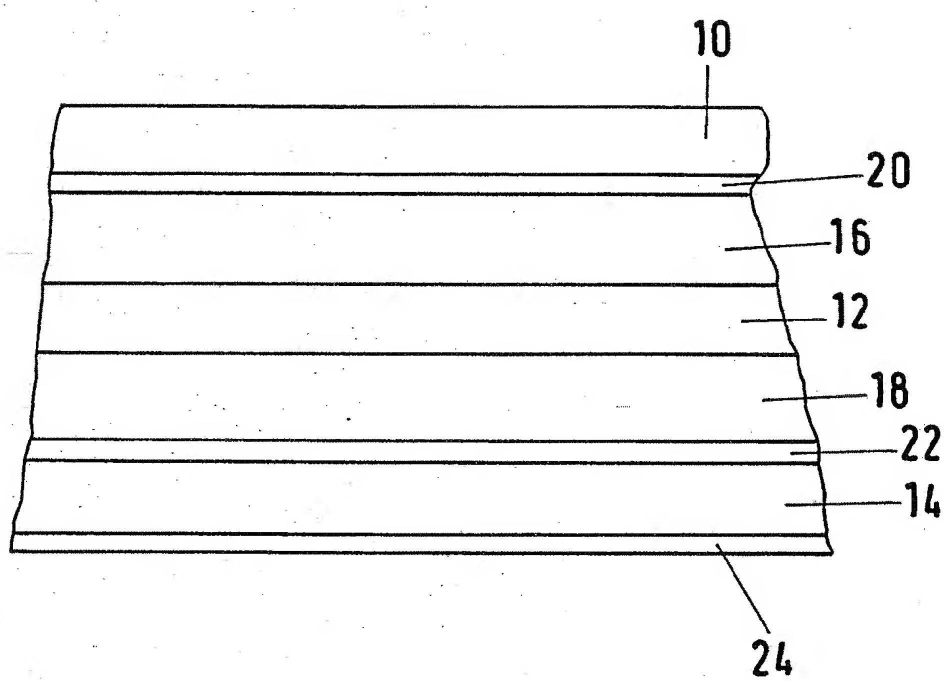

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Description of Invention

"Multiple-sheet insulating glass for cold storage chambers"

THIS INVENTION relates to a multiple sheet insulating glass for a glazed door which separates a cold storage chamber having a relatively low air temperature from surroundings having a higher air temperature, the glass comprising an outer sheet facing the surroundings and an inner sheet facing the cold storage space and separated from the outer sheet by means of an intermediate space which may be subdivided into a plurality of intermediate sub-spaces by means of at least one intermediate sheet, the outer surface of the inner sheet facing away from the intermediate space being exposed to the atmosphere of the cold storage chamber.

Multiple sheet insulating glasses of the type described above are used principally for window-like doors, which are used to separate-off cold storage chambers. This is for example the case with a refrigerated display case, in which a large-area view of the goods stored in the cold storage chamber is desirable and in which the door can be opened for a short time in order to take out frozen goods.

Such refrigerated display cases have inner temperatures in the region of approximately 10°C to -30°C, depending upon the specific application. Because of the low temperature within the display case, good thermal insulating of the glazing is necessary in order to keep the cooling power required as low as possible. For this reason, a multiple sheet insulating glass is

generally used as a glazing for such applications. In practice, a triple structure with two air spaces, each 6 mm wide for example, is used. In this connection an important aspect is the fact that the total thickness of the multiple sheet insulating glass should be as small as possible, so that the resulting glazed doors are not too expensive in constructional terms. A problem with such glazings in refrigerated display cases is the formation of condensation on the side of the outer sheet facing the surrounding room, as a result of which the view of the interior of the display case is impeded in a troublesome way. With the low temperature inside such refrigerated display cases, the temperature of the outer sheet is so far below the normal ambient temperature in the display room of approximately 20 - 25°C that, with the relatively high air humidity of such rooms of approximately 50 - 70%, it falls below the dew point temperature and moisture is deposited on the outer sheet. In order to prevent such condensation, the outer sheet of the triple structure is heated so as to keep its temperature above the critical dew point temperature. The heating takes place by means of an electrically conducting, light-permeable coating, which is deposited on the side of the outer sheet facing the air space. Considerable extra expenditure is incurred for this heating as a result of the coating, the requisite current feeds and the electrical supply. In addition, there is the energy consumption for this heating.

For this reason it would in principle be desirable to have a multiple sheet insulating glass for the application referred to above in which the degree of thermal insulating is so high that the temperature of the outer sheet no longer falls below the critical dew point temperature and thus the heating of the outer sheet can be completely dispensed with or at least the temperature of the outer sheet can be increased to such an extent

that the requisite heating power is considerably reduced. In addition, with such a highly insulating glazing, the requisite cooling power of the refrigerated display case would also be considerably lower.

There are various measures or combination of such measures that might be employed in order to improve the thermal insulation of a multiple sheet insulating glass. The first possibility is to increase the number of insulating intermediate spaces. This is however generally not practicable beyond a triple structure with glazings for the doors of refrigerated display cases, as the overall thickness of such doors should be as small as possible for constructional and weight reasons. Further possibilities for improving thermal insulating include filling the intermediate space or intermediate spaces with a gas having a lower thermal conductivity than air, evacuating such intermediate spaces and applying infra-red reflecting, light permeable coatings to the surface of the glass sheets facing the intermediate space or intermediate spaces. Such measures have for example been proposed in DE-OS 24 43 390 to improve the thermal insulation of window panes for the building sector. Such measures are also already known in glazings for cold storage chambers (for example, of the type described in DE-OS 26 44 523, DE-OS 28 42 045 or EP-OS 0 036 657). By means of the combination of the two latter measures, the thermal insulation of a glazing can be improved considerably, without the total sheet thickness notably exceeding the triple structure previously mentioned with two air spaces of 6 mm width, a coefficient of thermal transmission k (k-value) of approximately 2.4 W/m^2k being obtained. A comparable k-value of 2.2 W/m^2k is obtained with a double structure with an air space of 12 mm, in which the outer sheet has a light-permeable, infra red-reflecting coating made of gold on the side facing the intermediate

space, which at the same time serves as a heating coating, in order to eliminate the formation of condensation on the outer side of this sheet.

In this context, the coefficient of thermal transmission k is the heat-flux density, based on the temperature difference of the spaces bordering the glazing on both sides. Thus three factors must be taken into account in the coefficient of thermal transmission: The aspect of the glazing itself and the aspects of the air layers adjacent to the warm and cold sides of the glazing in accordance with the following formula

$$k = \frac{1}{1/\alpha_i + 1/\alpha_a + R}$$

wherein: R = the resistivity to heat of the glazing,

α_a, α_i = coefficients of thermal transmission towards the outside (a) or inside (i)

When quoting k-values, the values for the coefficients of thermal transmission are standardised according to average conditions for a vertical glazing in the building sector to $\alpha_a = 23\ W/m^2k$ and $\alpha_i = 8W/m^2k$.

All k-values given below relate to these standardised boundary conditions. It goes without saying that in practice the actual values in the case of refrigerated display cases can deviate from this slightly. Thus the coefficient of thermal transmission α_a between the glazing and the surrounding room will depend amongst other things upon the display conditions and the air flows in the display room. The same applies to the coefficient of thermal transmission towards the inner space of the refrigerated display case α_i. The latter too is amongst other things slightly dependent on

the dimensions of the refrigerated display case in question and also upon the degree of forced air circulation, which is always present with these refrigerated display cases in order to render the temperature within the display case more uniform. In this connection, it should however be borne in mind that, for the range of the low k-values of interest in this case below 2 W/m^2k, the effect of the adjacent air layers on the k-value is relatively small. The insualting effect in this range is essentially determined by the high resistivity to heat of the glazing, and therefore quoting the k-values under the standard conditions referred to represents an adequate indication.

As already stated, the k-value of glazings for refrigerated display cases can be reduced considerably, in particular by using a filler gas with a lower thermal conductivity in combination with an infra red-reflecting coating, compared with the values above 2 W/m^2k, which were obtained with the arrangements referred to. Thus for example for a double structure, a k-value of 1.5 W/m^2k is obtained, when the 12 mm-wide intermediate space is filled with argon and a light-permeable coating having an infra-red reflection capacity of 92% is applied to the surface of the outer sheet facing the intermediate space. Tests have in addition shown that with a triple structure an excellent k-value of 1 W/m^2k can be achieved. With this structure, the two intermediate spaces of 6 mm width are filled with krypton, and a light-permeable coating with an infra-red reflection capacity of 92% is applied on to the side of the outer/inner sheet facing the intermediate space.

By means of glazings with such low k-values, the cooling power required for a refrigerated display case can be reduced considerably. In addition, the temperature of the outer sheet of such a highly

insulating glazing is in most circumstances above the dew point temperature, so that the expensive heating of the outer sheet can be dispensed with. Whether this is the cae, depends of course on the relative air humidity in the display room and the inner temperature of the refrigerated display case. As the relative air humidity increases and the inner temperature of the refrigerated display case falls, lower k-values for the glazing are necessary, if the heating of the outer sheet is to be dispensed with. For normal applications, the k-values achieved are already adequate. Thus, for example, with a triple structure having a k-value of 1 W/m^2k, with an inner temperature of -20^oC in the refrigerated display case and an ambient temperature of 25^oC, the outer sheet is kept free of condensation up to a relative air humidity of 80%.

Tests carried out with such highly insulating glazings for refrigerated display cases have, however, shown an unexpected serious disadvantage in comparison with conventional glazings with k-values above 2 W/m^2k. If the door of such a refrigerated display case is opened in order to remove goods, an ice or water film with surface temperatures above 0^oC is formed on the surface of the inner sheet of the glazing facing the cold storage chamber as a result of contact with the ambient air. This takes place in the same way with conventional glazings with k-values slightly above 2 W/m^2k as well as with the extremely highly insulating glazings tested. Differences in the quantity deposited cannot, as expected, be detected, as in both cases the inner sheet temperature is well below the dew point temperature of the ambient air with the usual relative air humidities.

Once the door is closed, the film produced, which significantly impedes the view-through, disappears once again. This occurs with conventional glazings with k-

values above 2 W/m^{2}k and an opening time of 10 seconds within approximately one minute, if the relative air humidity is at approximately 65%. In the case of the highly insulating glazings, this condensation period is considerably longer. The condensation period is increased by a factor of approximately 2.5, if a glazing with a k-value of 1 W/m^{2}k is used.

The observed increase in the condensation period is a considerable disadvantage of such highly insulating glazings in practice, because during this period an unimpeded view through the door to the goods an offer is no longer possible. Essentially, this period should be kept as short as possible, and condensation periods of longer than 1 minute are normally not acceptable for these applications.

The invention aims to make available a highly insulating multiple sheet insulating glass with which an unimpeded view-through is guaranteed once again as short a time as possible after opening and reclosing of the cold storage chamber door.

This problem is solved in accordance with the invention by the fact that in a multiple sheet insulating glass for a cold storage chamber with forced air circulation and having a coefficient of thermal transmission of less than 2 W/m^{2}k, preferably less than 1.6 W/m^{2}k, the outer surface of the inner sheet of the glass is provided with an infra-red reflecting coating, the thermal reflectivity of which is more than 50% in the wavelength range above approximately 4 µm.

The thermal reflectivity of the infra-red reflecting coating is preferably more than 70%.

The infra-red reflecting coating may be made of

doped tin oxide and/or doped indium oxide.

In another embodiment of the invention, the infra-red reflecting coating is a metal coating made of silver, copper or gold, which has a dielectric anti-reflection coating on the side remote from the inner sheet.

The dielectric anti-reflection coating may be made of metal oxide.

The reduced condensation time achieved by means of such a coating on the inner sheet of the multiple sheet insulating glass in the case of highly insulating glazings for cold storage chambers with forced air circulation is an astonishing result.

Admittedly glazings are known, which divide colder from warmer space and which have an infra-red reflection coating on the sheet surface facing the colder space. Thus in accordance with DE-05 28 33 234 the formation of ice during cold nights on the outer surface of toughened automotive glazings is reduced by such a coating. As already stated above and as the tests set out below confirm, the arrangement in accordance with the invention of an infra-red reflecting coating on the outer surface of the inner sheet of a highly thermal insulating cold storage chamber glazing can in contrast to this not directly produce reduced formation of ice. The solution to the problem underlying the invention can therefore not be taken from this prior Patent.

In accordance with DE-OS 28 42 045, a refrigerated display case glazing is improved with regard to its thermal insulation as a result of the arrangement of an infra-red reflecting coating on the outer surface of the inner sheet, only if the refrigerated display case is horizontally glazed and no forced air circulation is

carried out. In contrast to this, for refrigerated display cases with forced air circulation, to which this invention relates exclusively, it is expressly emphasized that the arrangement of an infra-red reflecting coating on the outer surface of the inner glass sheet has disadvantages compared with multiple insulating glass units, in which infra-red reflecting coatings are arranged only on the sheet surface facing the intermediate space. DE-OS 28 42 045 thus provides a theory which leads directly away from the invention; this also applies to EP-OS 0 036 657, which also expressly recommends that the infra-red reflecting coatings be arranged in such a way that they cannot solve th eproblem forming the basis of the present invention, namely on the sheet surfaces facing the intermediate space or one of the intermediate spaces.

Various materials can be used for the light-permeable infra-red reflecting coating on the outer surface of the inner sheet of the glazing facing the cold storage chamber, i.e. the inner space of the refrigeration display case. In particular doped tin and indium oxide coatings are suitable, such coatings being characterised by a high degree of light permeability in conjunction with high infra-red reflection and being mechanically very stable. Also suitable are, for example, thin coatings made of the metals gold, copper and silver, in particular multiple coatings, in which these metal coatings are embedded on both sides in interference layers, in order to increase the light permeability and also to improve the mechanical and chemical resistance.

In order that the invention may be readily understood, an embodiment thereof will now be described in greater detail with reference ot the accompanying drawing the figure of which illustrates one example of a

multiple sheet insulating glass embodying the invention in section perpendicular to the plane of the sheets.

As is apparent from the drawing, the multiple sheet insulating glass illustrated therein has an outer sheet 10, an intermediate sheet 12 and an inner sheet 14, each of which is made of silica glass and has a thickness of 4 mm. Between the outer sheet 10 and the intermediate sheet 12 on the one hand, and between the intermediate sheet 12 and the inner sheet 14 on the other there are an outer, gas-filled intermediate space 16 and an inner gas-filled intermediate space 18. The two intermediate spaces 16, 18 are each 6 mm wide and are filled with krypton. On the surfaces of the outer sheet 10 and the inner sheet 14 facing the respective intermediate spaces 16 and 18, there are light-permeable infra-red reflection coatings 20 and 22 having a thermal reflection capacity of 92%. On the outer surface of the inner sheet 14 which, in use, faces the cold storage chamber, there is a further light-permeable infra-red reflecting coating 24 also having a thermal reflection capacity of 92%, whereby the infra-red reflection coatings 20, 22, 24, in the embodiment shown are made of silver embedded in SnO_2 anti-reflection coatings.

The k-value of the multiple sheet insulating glass described above and shown diagrammatically in the drawing is 1 W/m^2k.

In order to prove the way in which the infra-red reflecting coating 24 on the surface of the inner sheet 14 facing the cold storage space works in accordance with the invention, a comparative test was carried out on a front-glazed deep freeze display case. The deep freeze display case had two window-like doors of identical dimensions, one of which was glazed with a multiple sheet insulating glass embodying the invention as described

above, with dimensions of 71 cm x 127 cm. The other door was glazed with a multiple sheet insulating glass having identical dimensions, but of a modified structure, in which the infra-red reflecting coating was omitted from the surface of the inner sheet 14 facing the cold storage space. Otherwise, the comparative glazing had an identical structure to the embodiment of the invention described above.

With the inner temperature of the refrigerated display case at -21°C and the ambient temperature at 25°C and with high relative air humidity of 75%, there was no formation of condensation on the side of the outer sheet 10 facing the atmosphere of either glazing. Both doors were then opened simultaneously for 10 seconds. This was carried out with relative air humidity of the ambient air at 60%. An ice film formed on that side of the inner sheets 14 of both glazings which faced the inner chamber of the refrigerated display case. Considerably impeding any view through the doors. The impedence was substantially identical for both glazings.

Following the simultaneous closure of both doors, the glazing with the additional infra-red reflecting coating 24 in accordance with the invention was iced up for a period of 60 seconds, whilst this period was 110 seconds in the case of comparative glazing without an infra-red reflection coating 24. This shows that the period the glazing is covered over can be reduced by approximately a factor of 2 by the measure provided in accordance with the invention, which in comparison with the teaching of DE-OS 28 42 045 could only be adopted by overcoming a preconception.

CLAIMS:

1. Multiple sheet insulating glass for a glazed door which separates a cold storage chamber having a relatively low air temperature from surroundings having a higher air temperature, which glass comprises an outer sheet facing the surroundings and an inner sheet facing the cold storage space and separated from the outer sheet by means of an intermediate space which may be subdivided into a plurality of intermediate sub-spaces by means of at least one intermediate sheet, the outer surface of the inner sheet facing away from the intermediate space being exposed to the atmosphere of the cold storage chamber, the glass being used for a cold storage chamber with forced air circulation and having a coefficient of thermal transmission of less than 2 W/m^2k, preferably less than 1.6 W/m^2k, in which glass the outer surface of the inner sheet is provided with an infra-red reflecting coating, the thermal reflectivity of which is more than 50% in the wavelength range above approximately 4 µm.

2. Multiple sheet insulating glass according to claim 1, wherein the thermal reflectivity of the infra-red reflecting coating is more than 70%.

3. Multiple sheet insulating glass according to claim 1 or 2, wherein the infra-red reflecting coating is made of doped tin oxide and/or doped indium oxide.

4. Multiple sheet insulating glass according to claim 1 or 2, wherein the infra-red reflecting coating is a metal coating made of silver, copper or gold, which at least on the side remote from the inner sheet has a dielectric anti-reflection coating.

5. Multiple sheet insulating glass according to claim

4, wherein the dielectric anti-reflection coating is made of metal oxide.

6. Multiple sheet insulating glass substantially as hereinbefore described with reference to the accompanying drawing.

7. Any novel feature or combination of features disclosed herein.

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